



OPTICAL, ATOMIC/ MOLECULAR AND LASER PHYSICS

Optical sciences and the basic properties of atomic and molecular interactions are becoming increasingly important to critical technologies for the Department of Defense. We are actively engaged in experimental research in the areas of lasers, non-linear optics, spectroscopy, and chemical kinetics. Particular applications include chemical and gas lasers, directed energy weapons, remote sensing, and optical diagnostics for manufacture of high temperature superconductor materials. Currently three faculty members and eleven graduate students are pursuing research in these areas. Current experimental programs are using laser induced fluorescence, photolysis, Fourier transform spectroscopy, thin film deposition and laser ablation techniques, diode laser, molecular beam, fast visible and near IR imaging, and chemical flow tube techniques to study the fundamental problems in chemical physics. In addition, nonlinear optics techniques are being investigated for applications in high energy lasers. Specifically, nonlinear optical effects in optical fibers are used to develop beam combining and cleanup systems as well as phase conjugation systems. Several specific projects are discussed below.

The development of beam cleanup and combining techniques is essential to laser brightness/energy scaling many solid-state (such as fiber lasers) and semiconductor diode lasers for high energy applications. Nonlinear scattering processes such as stimulated Brillouin scattering and stimulated Raman scattering in optical fibers offer a promising means of achieving the goal. They are the subject of a very active research program in the department at this time. Furthermore, the same scattering processes are also used for an efficient phase conjugation technique, which is required for phasing the output beams of a multi-channel master oscillator/power amplifier system.

The Airborne Laser program depends on the Chemical Oxygen-Iodine Laser (COIL) as the weapon to intercept theater missiles during the boost phase. We are developing optical diagnostics to assess the performance and efficiency of the COIL device. In particular, a variant of laser saturation spectroscopy is being employed to determine the spatially resolved temperature at the exit plane of the COIL supersonic mixing nozzles. In addition, hyperfine and velocity relaxation in molecular iodine is being investigated. In addition, the kinetics of producing electronically excited molecular oxygen via discharge techniques is being investigated as part of a multi-university research initiative to develop a closed cycle chemical laser.

Remote sensing of the infrared and visible emissions from bomb explosions, missiles launches and muzzle flashes may be used to characterize the battlespace. A fieldable FTIR spectrometer has been used to record the temporal and spectral signatures from conventional munitions detonations. The signatures are correlated with detonation conditions to characterize and classify bomb type, size, etc.

Laser ablation deposition is a promising technique for growing high quality thin films. In particular, the Air Research Laboratory is interested in high temperature superconductors for aircraft power generation in support of high power microwave weapons. The current research centers on mechanisms responsible for fabrication of quality films and

manufacturing process control. Studies include spectroscopic investigations of plume dynamics, species monitoring as a function of distance, time, and ambient pressure, and plume - substrate interactions.

As laser weapons transition from the laboratory to the battlefield, the modeling and simulation of the entire weapon system and its effectiveness in destroying targets has become increasingly important. The research focuses on integrating models for the laser device, beam director, atmospheric propagation, and target lethality to provide an end-to-end system performance engagement model capable of assessing the impact of these new laser based weapons in various combat scenarios.

Energy transfer among small molecules in the gas phase has been an important field in chemical physics for several decades. However, vibrational and rotational energy transfer in strongly coupled systems is a difficult problem both theoretically and experimentally. Spectrally-resolved, temporally-resolved laser induced fluorescence techniques are being used to determine state-to-state energy transfer rates, with particular emphasis on the electronically excited states of the diatoms. The results are critical to characterizing chemical and gas phase lasers.

Spectral lineshapes are important to both laser development and remote sensing applications. Experimental studies of line broadening, line coupling, and rotational energy transfer are in progress using Fourier Transform Spectroscopy and Laser Induced Fluorescence techniques. The dependence of line broadening of visible and infrared transitions in I₂, HF, and NO on rotation and collisional energy transfer is of particular interest.

FACULTY:

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SOME RECENT PUBLICATIONS:

“Collisional dynamics of Bi₂ A(0_u⁺). II. State-to-state rotational energy transfer” Journal of Chemical Physics, 116, 4896 (2002), R.E. Franklin and G.P. Perram.

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